

The GOES-R AWG Volcanic Ash Products

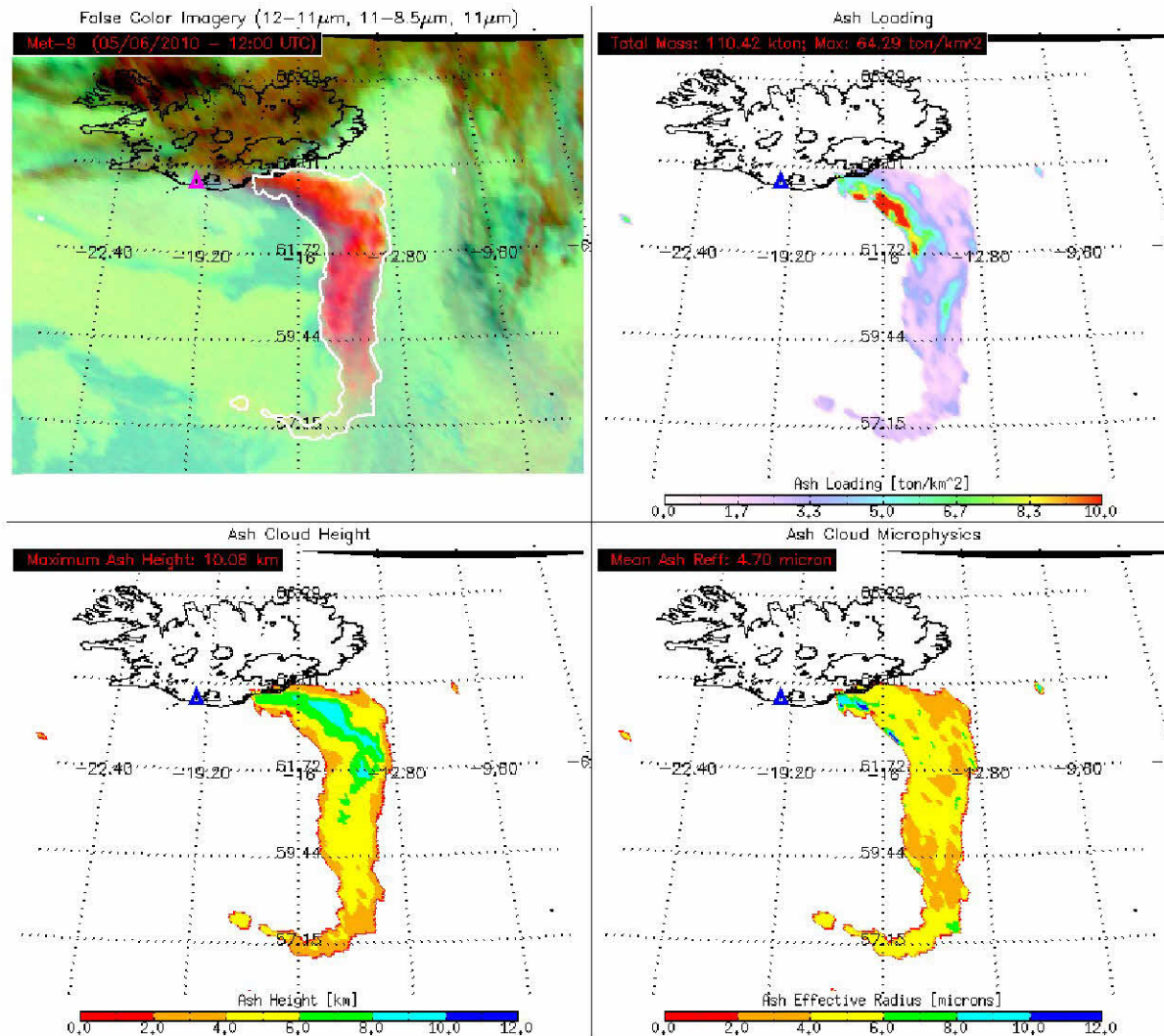
Mike Pavolonis (NOAA/NESDIS)
Justin Sieglaff (UW-CIMSS)



Outline

- **Introduction to the GOES-R AWG Volcanic Ash Products**
- **Known Limitations**
- **Examples**
- **PG Plans**

The GOES-R Volcanic Ash Products



- A three channel (11, 12, and 13.3 μ m) optimal estimation technique (e.g. Heidinger and Pavolonis, 2009) is used to retrieve the ash cloud height, mass loading, and particle size.

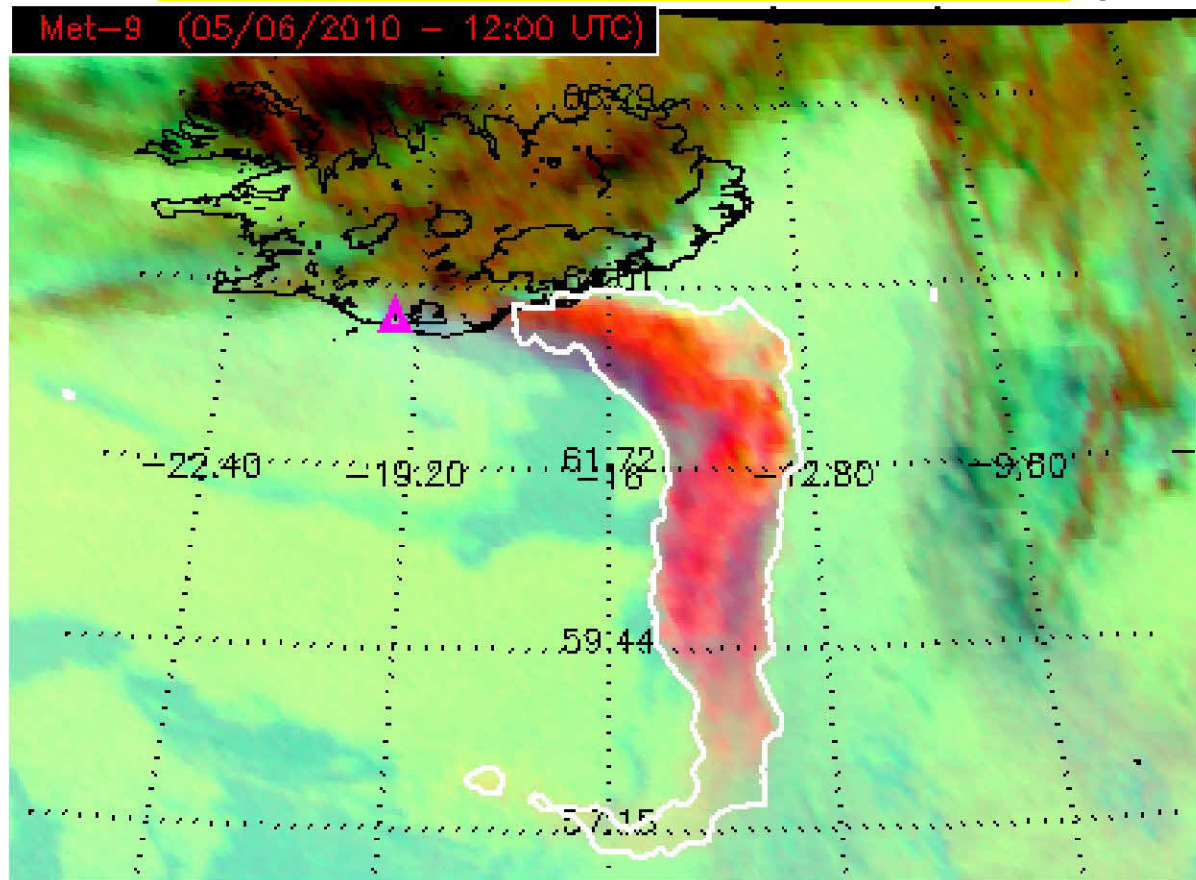
- These products are well suited for assimilation into models since the error estimate for each parameter is objectively determined by the algorithm.

- Product validation efforts indicate that we are meeting the accuracy specifications

- SEVIRI or MODIS can be used to generate the GOES-R products.

The GOES-R Volcanic Ash Products

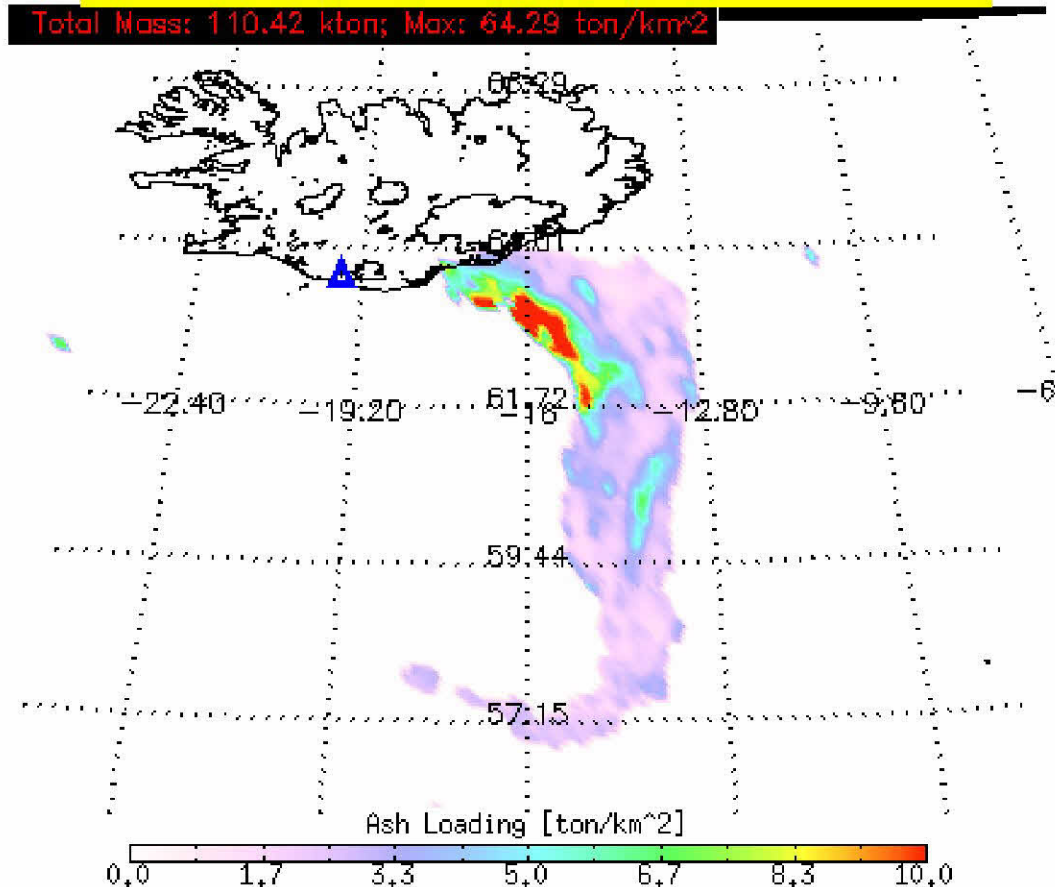
Quantitative Ash Detection



- Quantitative ash detection (e.g. Pavolonis 2010) is expressed as an ash confidence.
- Ash detection results can be overlaid on false color imagery to give the user perspective.
- The ash detection can be used to provide automated ash alerts.

The GOES-R Volcanic Ash Products

Ash Mass Loading



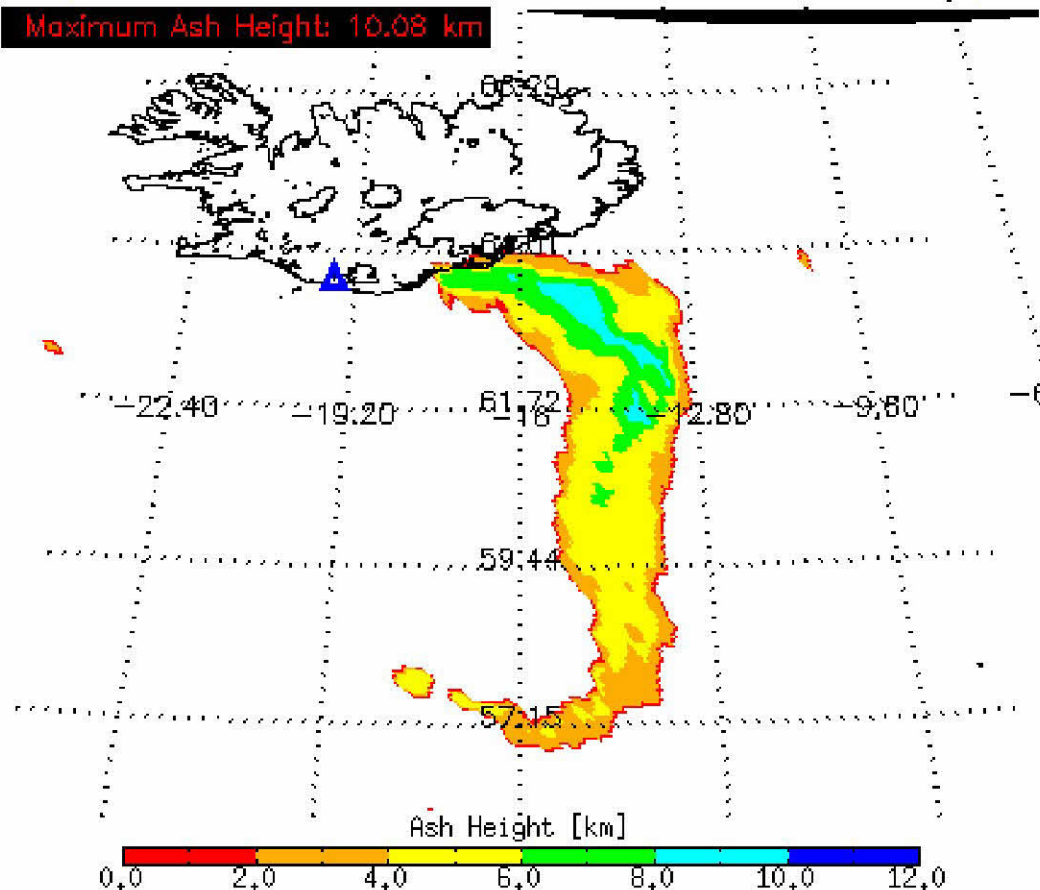
- Ash mass loading (ton/km²) is needed to determine if jet engine tolerances are exceeded and to initialize models.

- If a 1 km cloud thickness is assumed, the mass loading is numerically equivalent to ash concentration in mg/m³.

The GOES-R Volcanic Ash Products

Ash Cloud Height

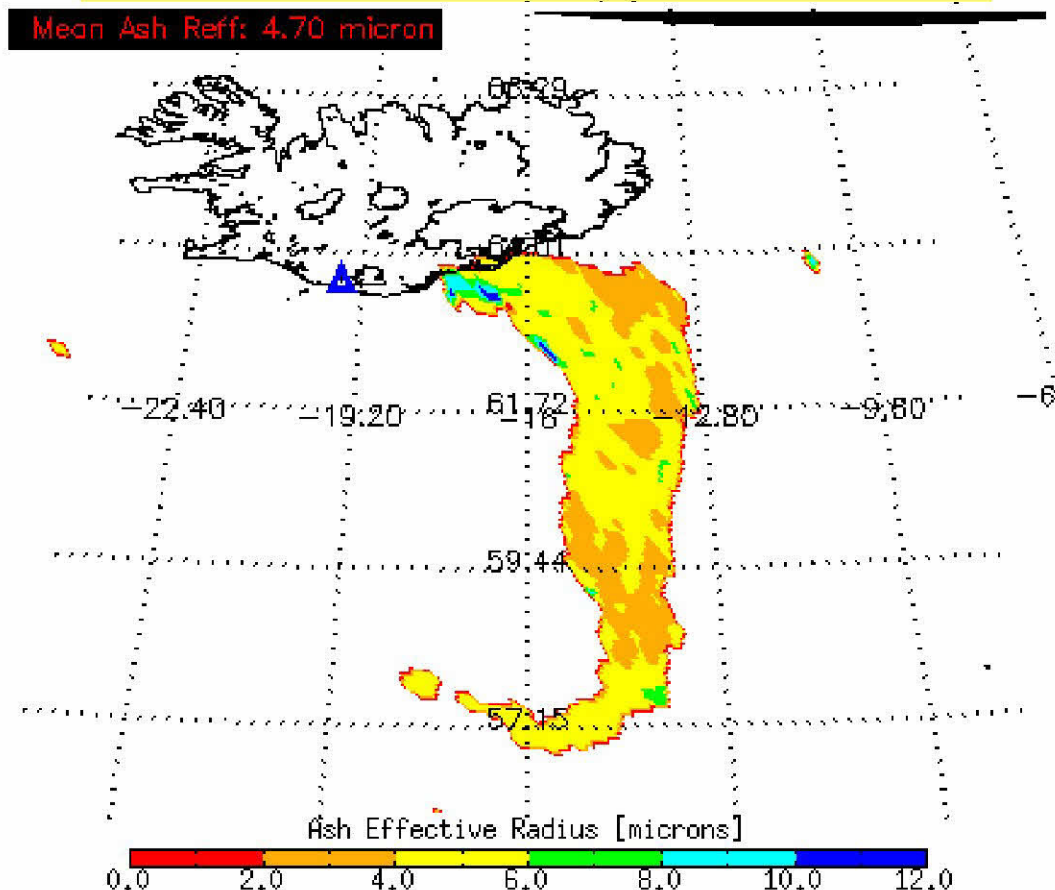
Maximum Ash Height: 10.08 km



- The ash cloud top height is critically important for determining if ash is at jetliner cruising altitudes (nowcasting component).
- In addition, the ash cloud height is a very important parameter for initializing dispersion models (forecasting component).

The GOES-R Volcanic Ash Products

Ash Effective Radius



- The ash cloud effective particle radius is not a required product, but it is automatically generated as part of the ash retrieval.
- Since the effective particle radius is well correlated with ash residence time, we will retain this information in quality flag form.

Primary Limitations

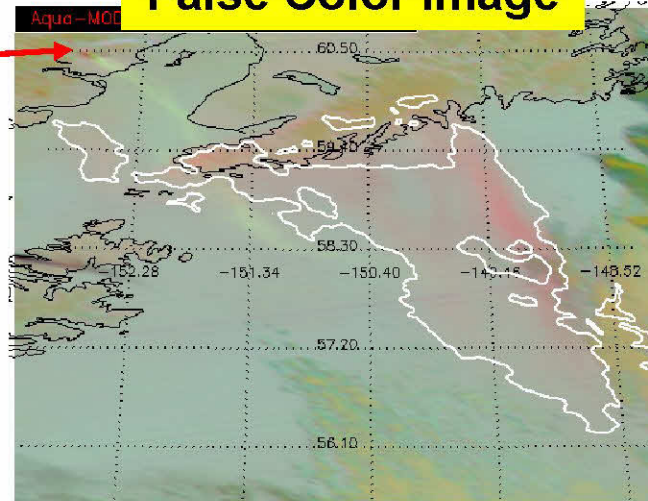
- **Passive sensor based algorithms can only detect volcanic ash and retrieve ash cloud properties when ash is the highest cloud layer.**
- **Underlying meteorological cloud layers sometimes contaminate the mass loading and effective particle radius retrievals.**
- **The minimum detectable ash concentration is about 1 mg/m³.**
- **It is very difficult to differentiate between volcanic ash and desert dust.**

Example GOES-R Volcanic Ash Products

Redoubt (4/4/2009 22:35 UTC)

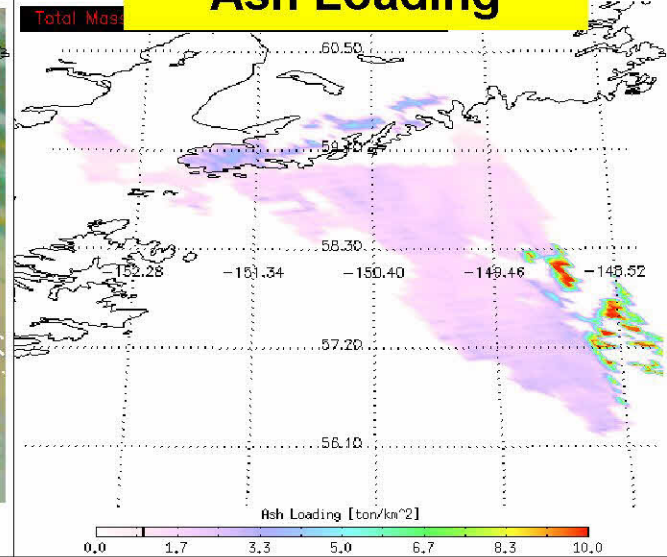
Redoubt →

False Color Image

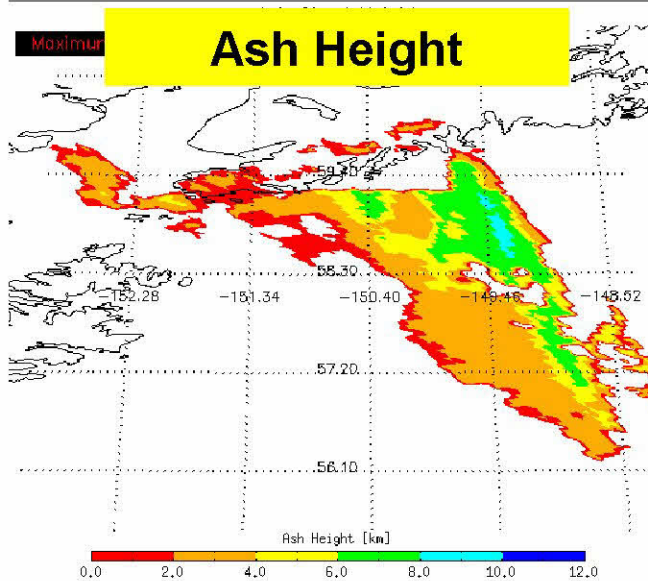


EXPERIMENTAL PRODUCT, Contact: Mike.Pavolonis@noaa.gov

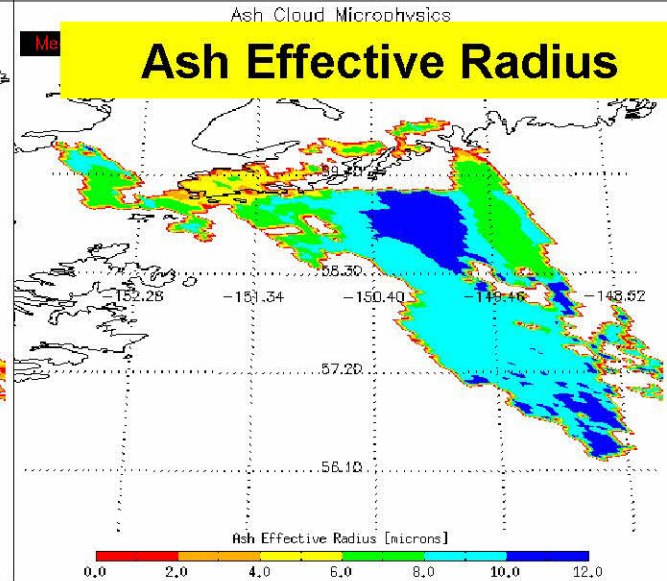
Ash Loading



Ash Height



Ash Effective Radius



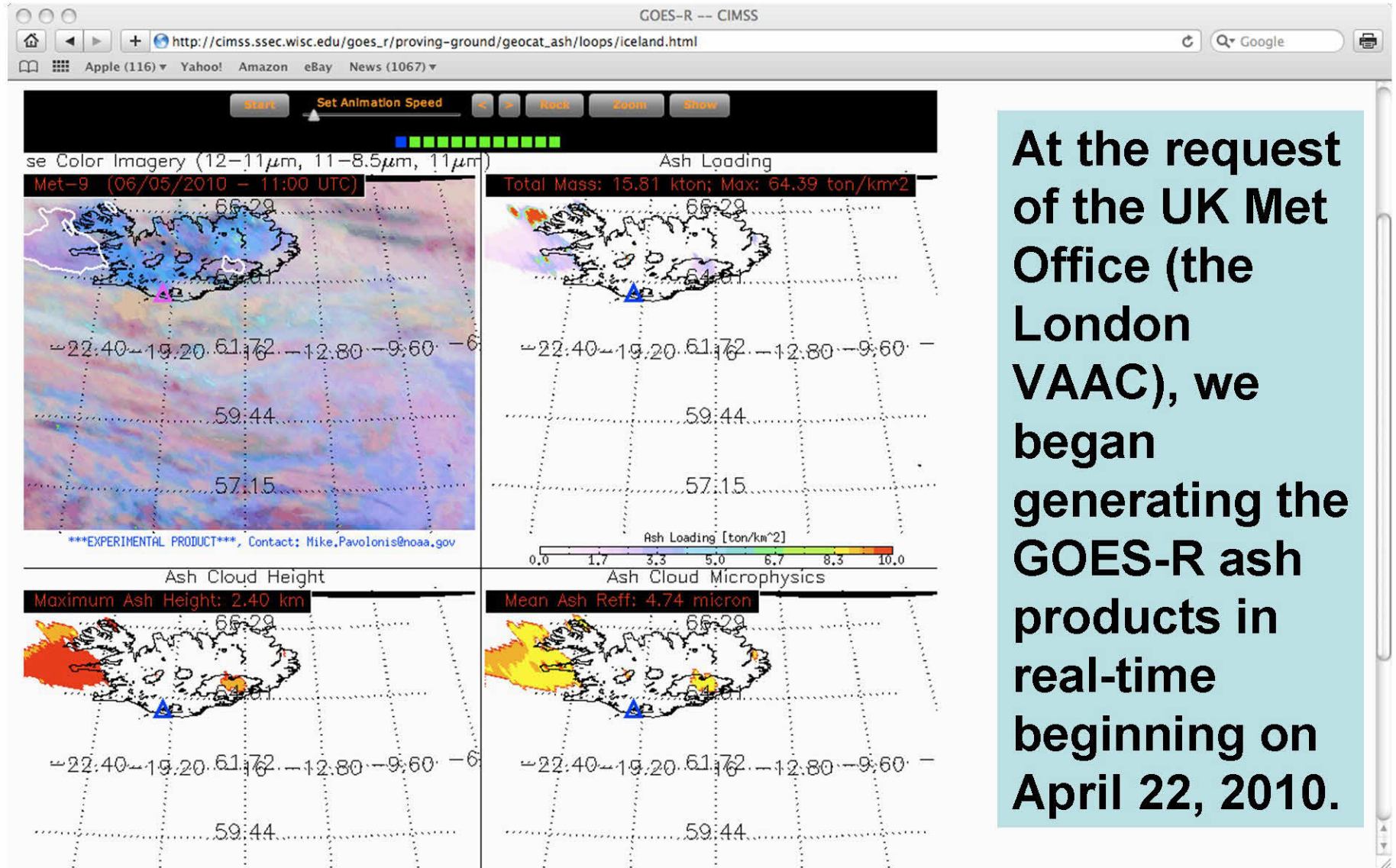
April 15 - April 20, 2010

•The GOES-R ash products were the only timely source of objective satellite derived ash cloud heights, loading, and particle size.

QuickTime™ and a
decompressor
are needed to see this picture.

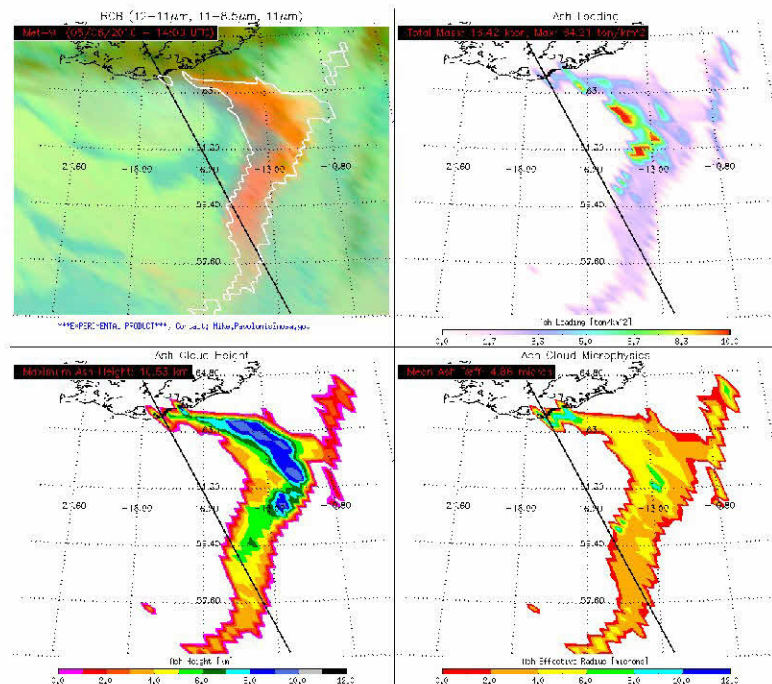
QuickTime™ and a
decompressor
are needed to see this picture.

http://cimss.ssec.wisc.edu/goes_r/proving-ground/geocat_ash/



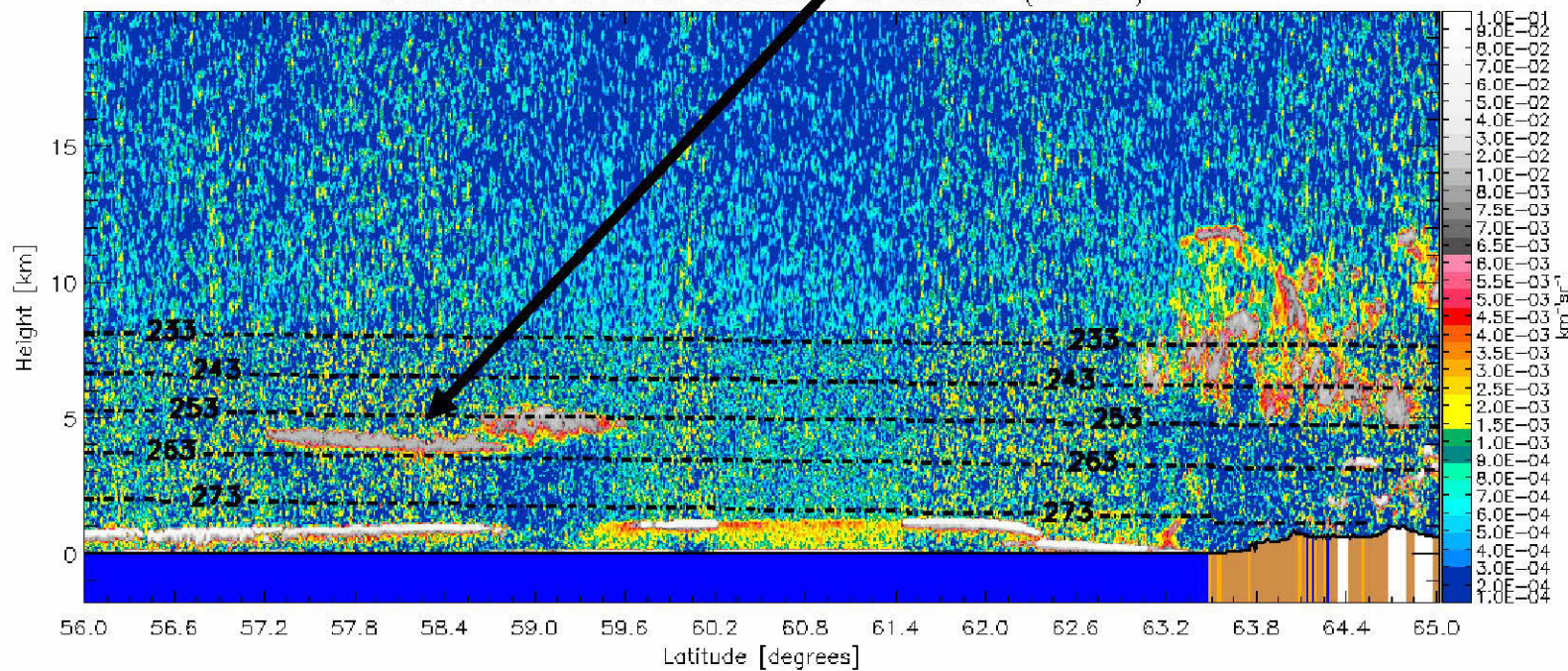
At the request of the UK Met Office (the London VAAC), we began generating the GOES-R ash products in real-time beginning on April 22, 2010.

May 6, 2010 (14:00 UTC)

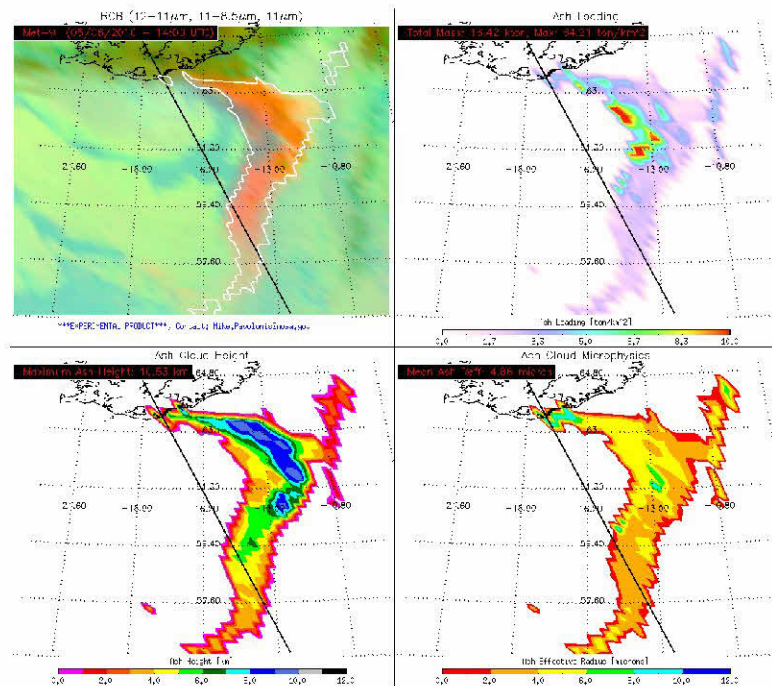


Ash cloud

CALIPSO 532 nm Total Attenuated Backscatter ($\text{km}^{-1}\text{sr}^{-1}$)

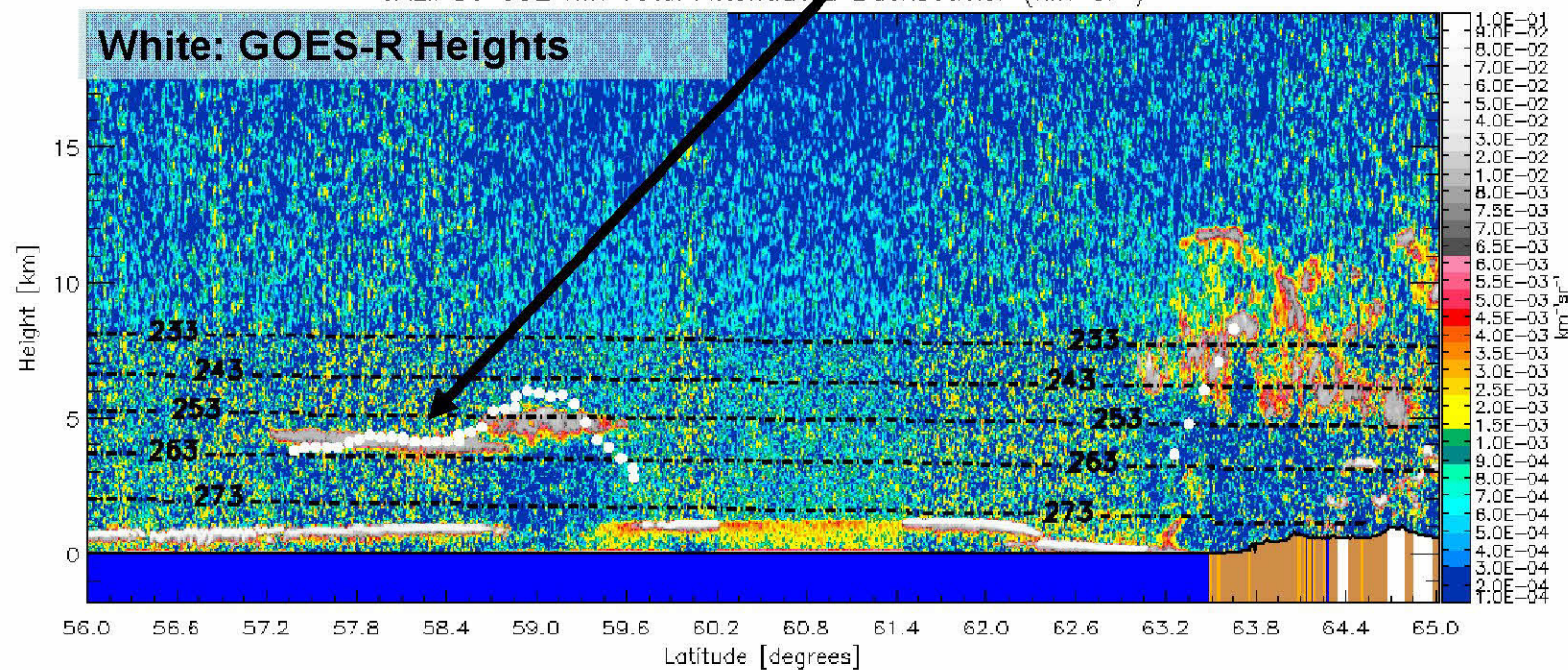


May 6, 2010 (14:00 UTC)



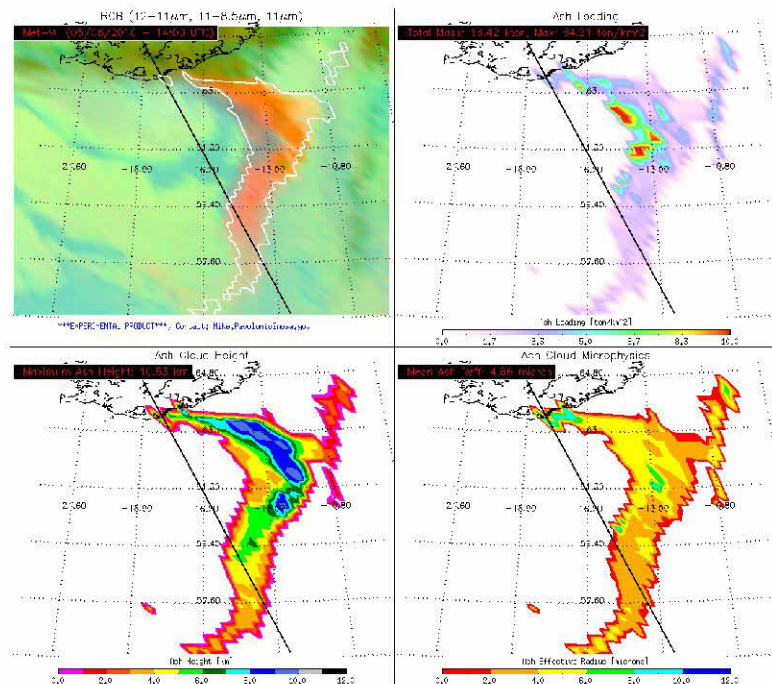
Ash cloud

CALIPSO 532 nm Total Attenuated Backscatter ($\text{km}^{-1}\text{sr}^{-1}$)



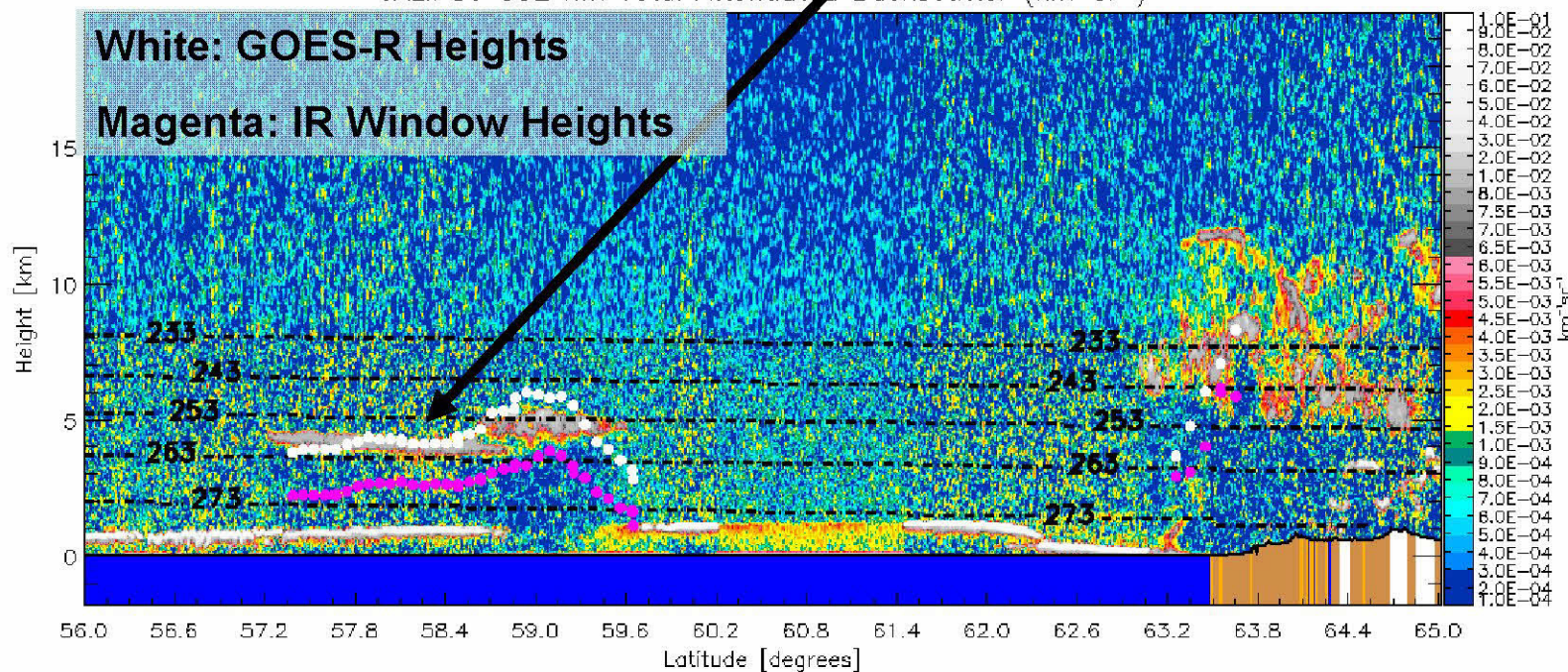
May 6, 2010 (14:00 UTC)

The GOES-R ash cloud heights closely match the CALIPSO cloud top boundary. The traditional methodology underestimates the cloud height.

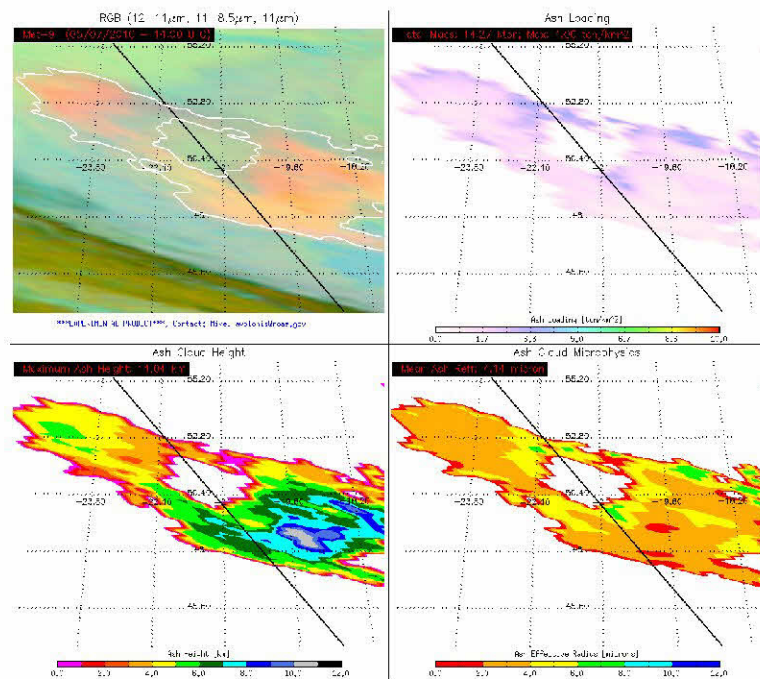


Ash cloud

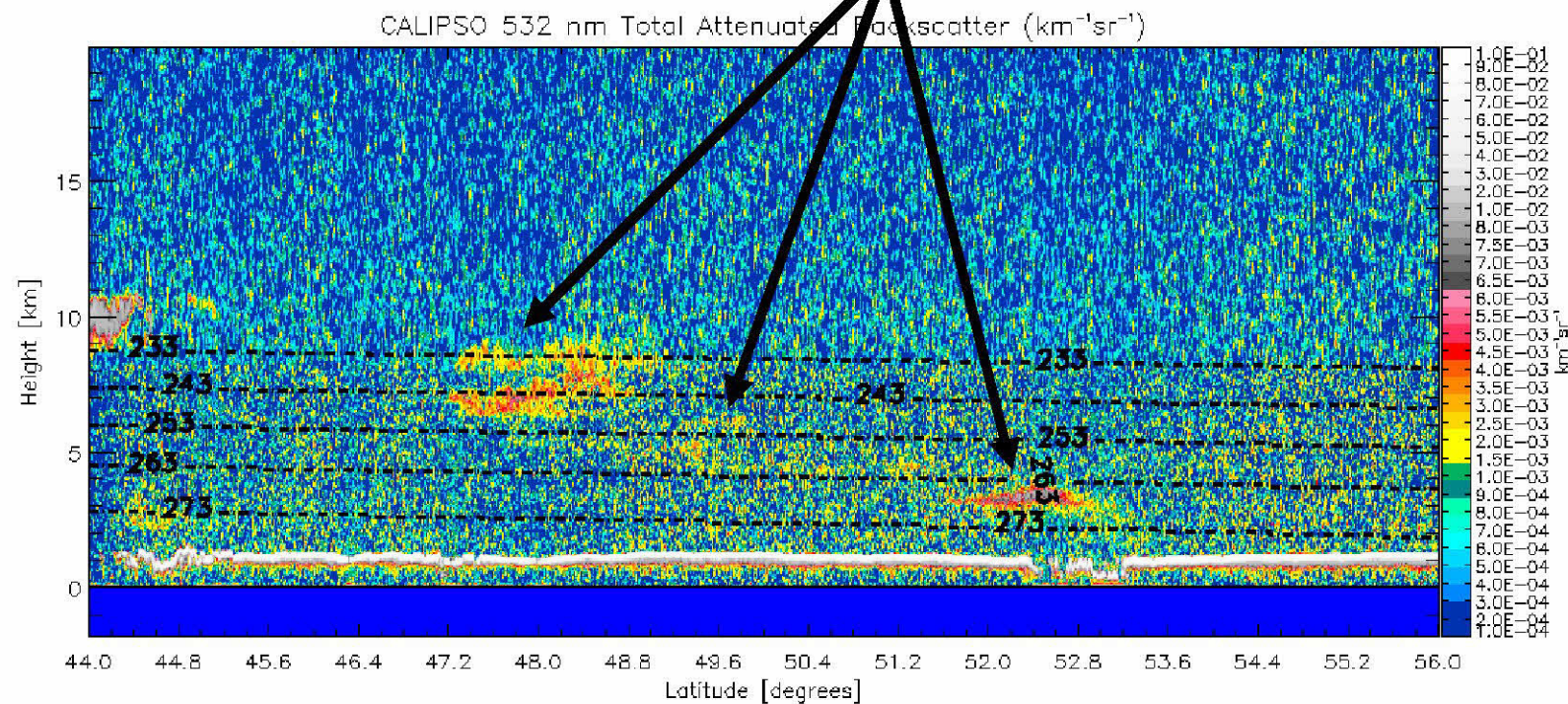
CALIPSO 532 nm Total Attenuated Backscatter ($\text{km}^{-1}\text{sr}^{-1}$)



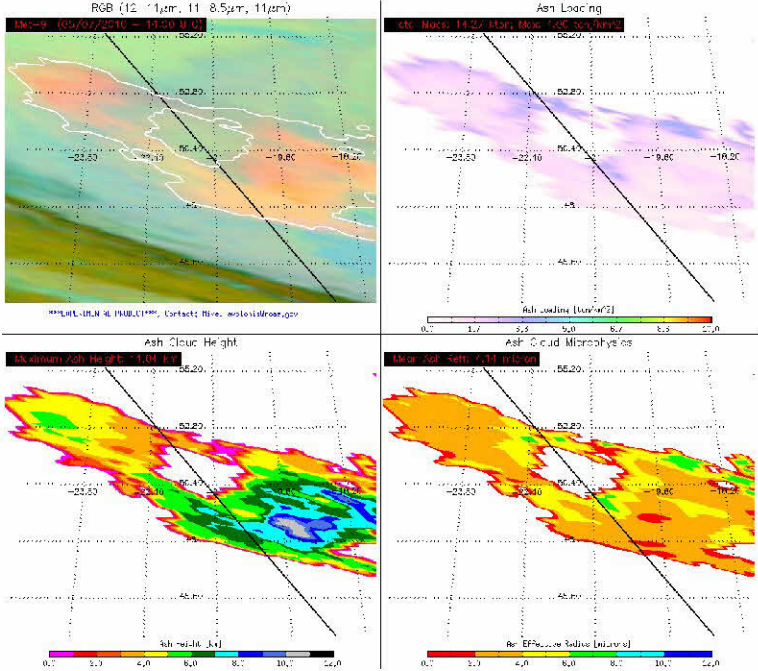
May 7, 2010 (14:00 UTC)



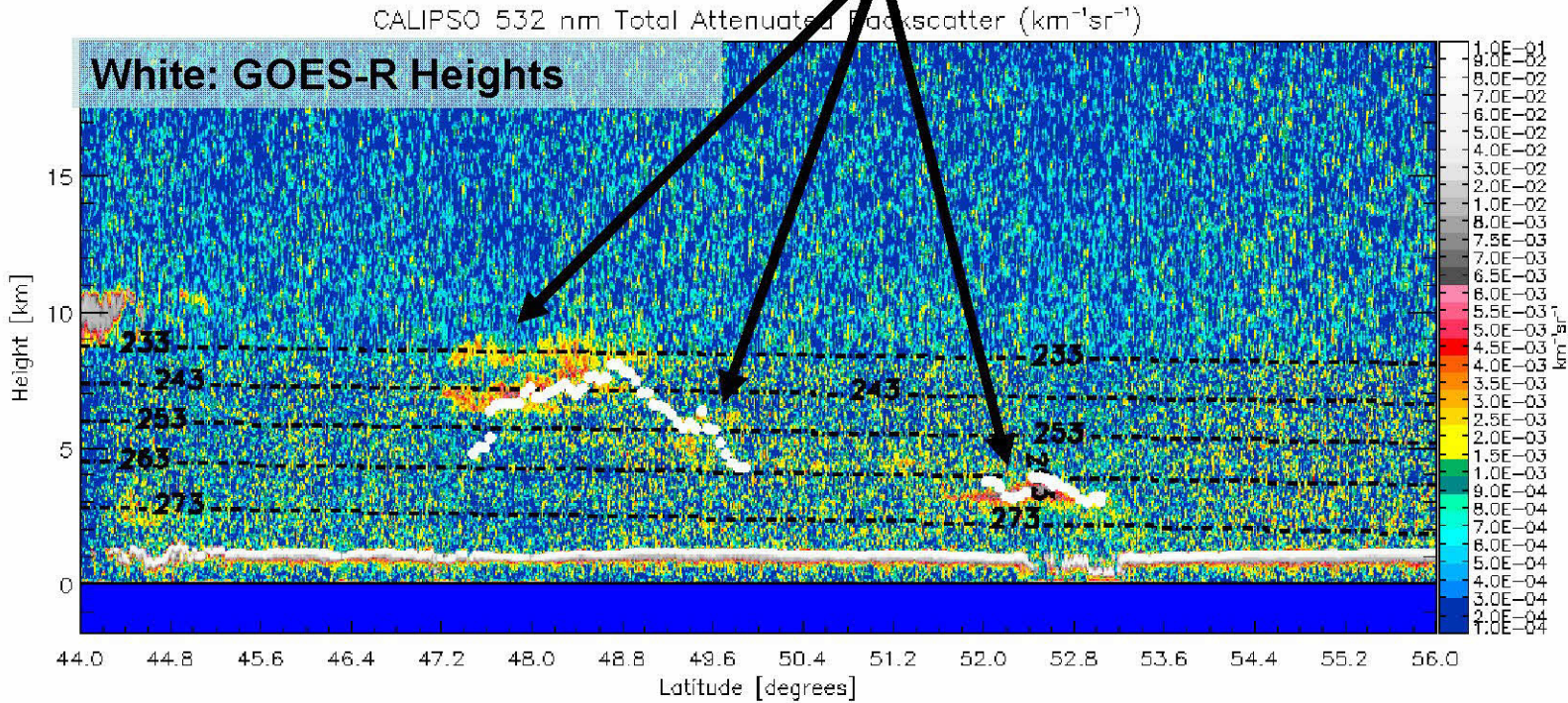
Ash clouds



May 7, 2010 (14:00 UTC)

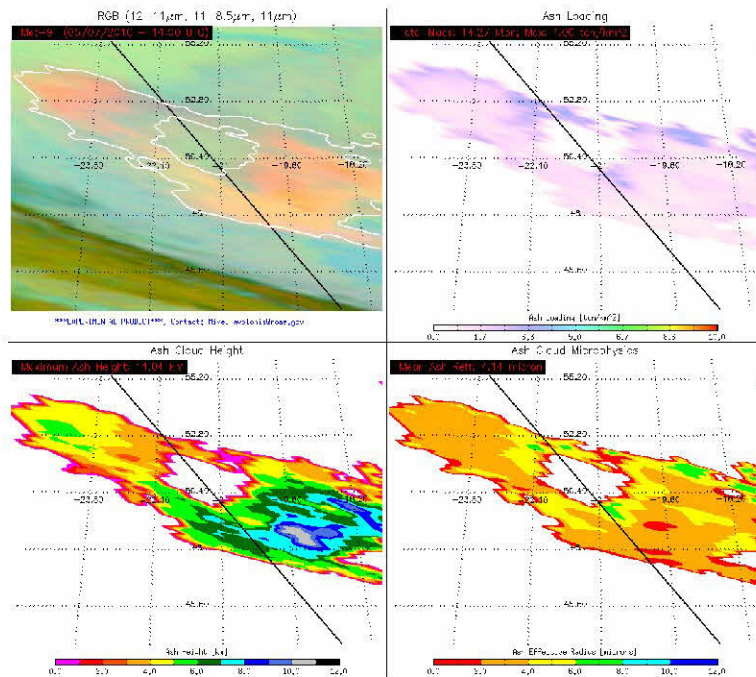


Ash clouds

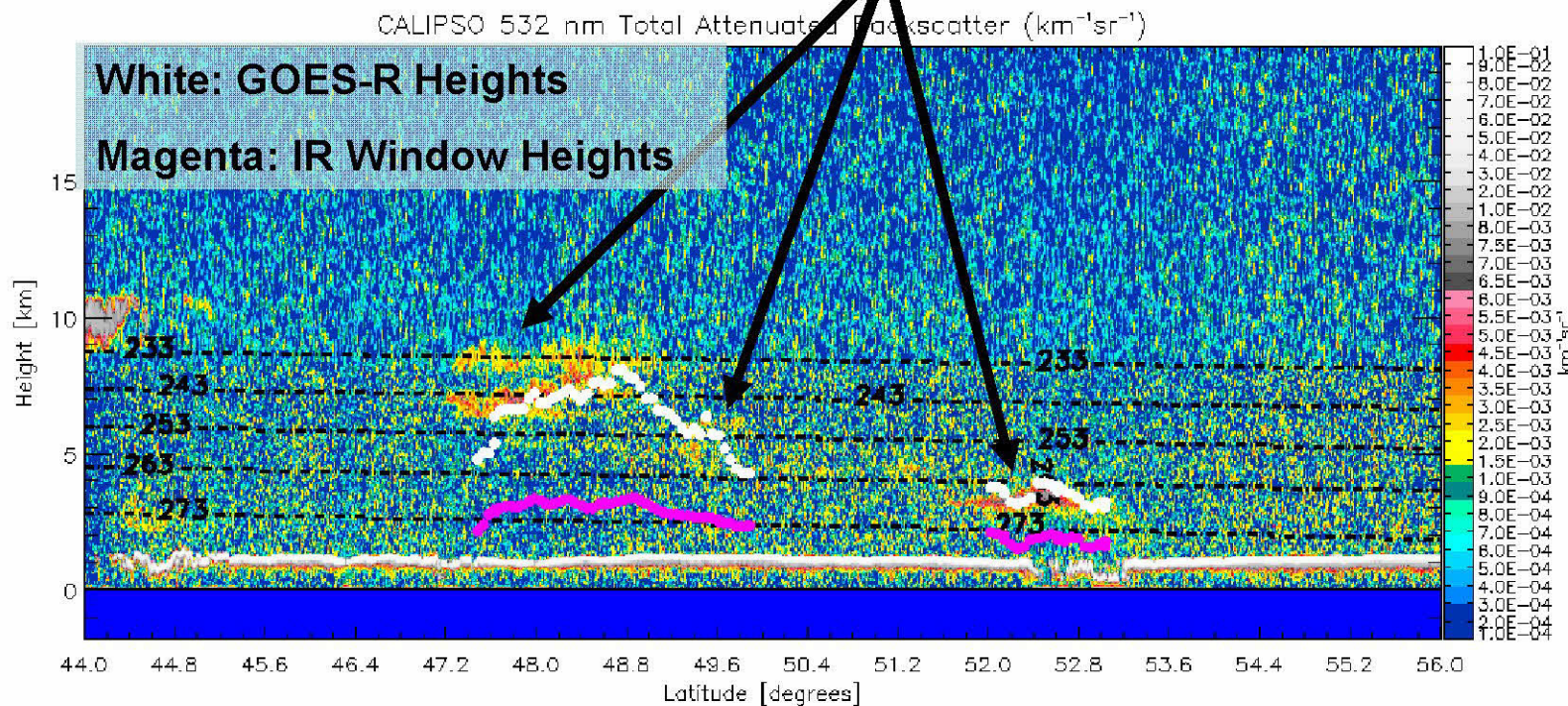


May 7, 2010 (14:00 UTC)

Even though these clouds are very optically thin, the GOES-R ash cloud heights closely match the CALIPSO cloud top boundaries, unlike the IR window based height.



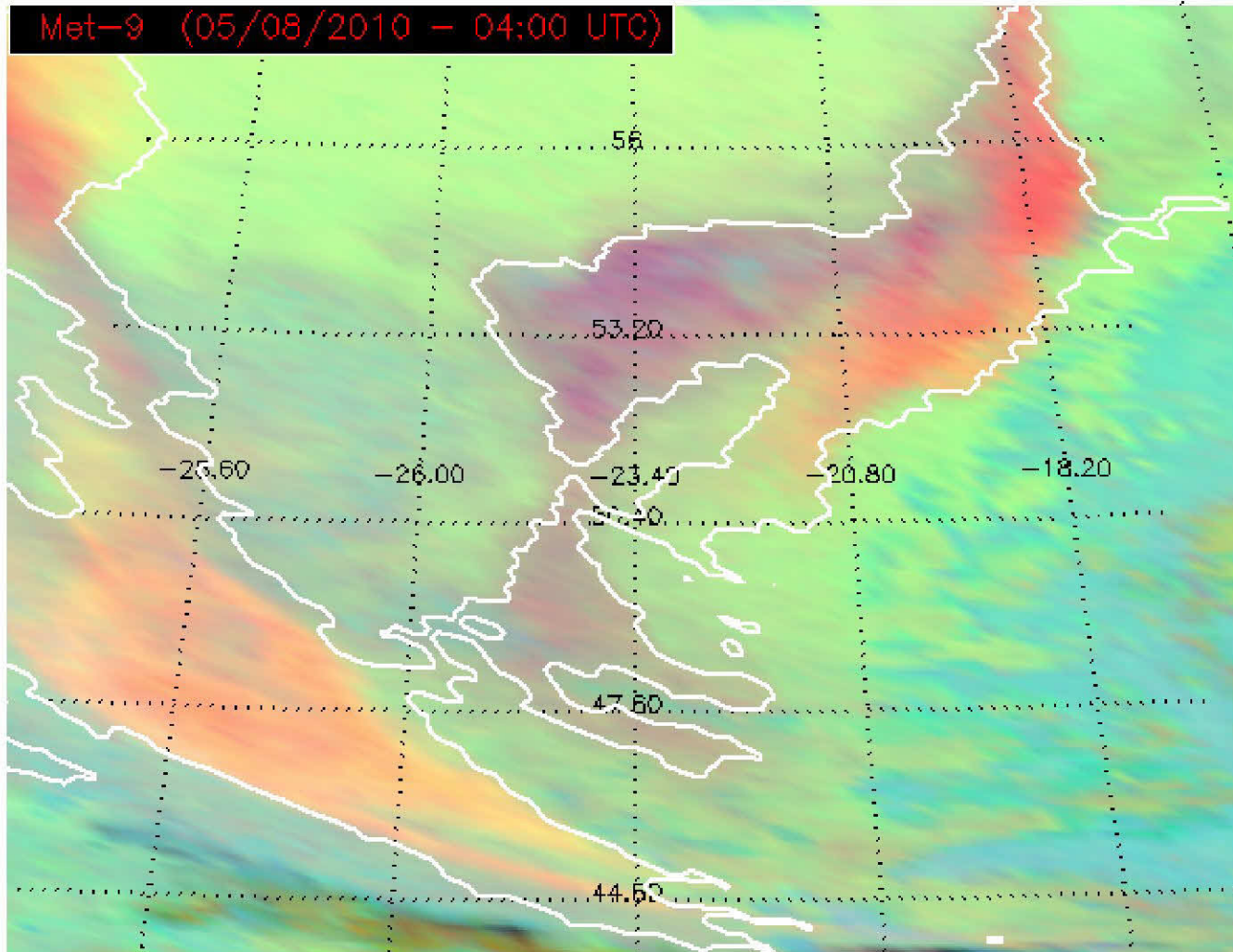
Ash clouds



SEVIRI, $\theta_{\text{sat}} > 65.0^\circ$

Now you see it...

RGB (12–11 μm , 11–8.5 μm , 11 μm)

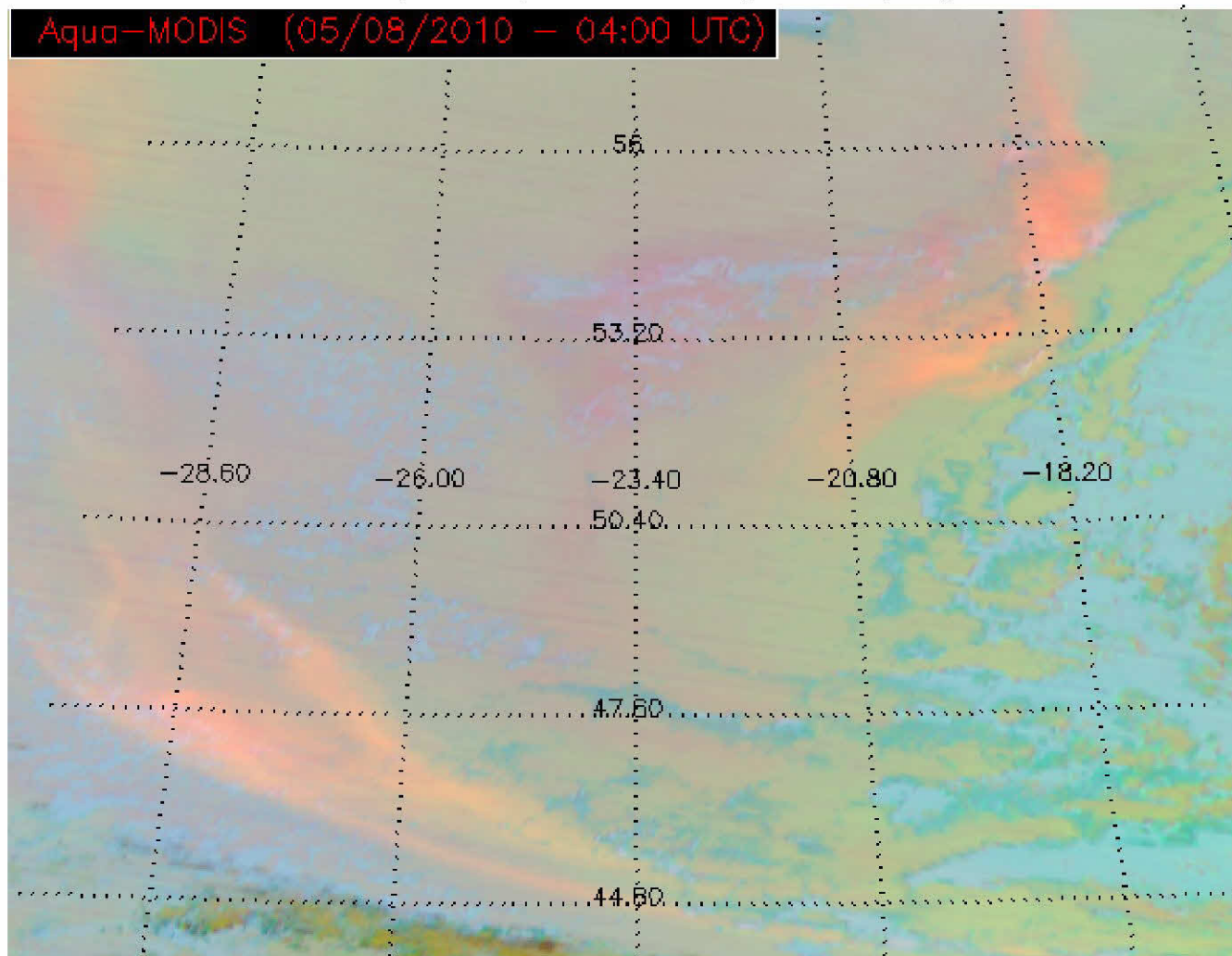


MODIS, $\theta_{\text{sat}} < 30.0^\circ$

Now you don't...

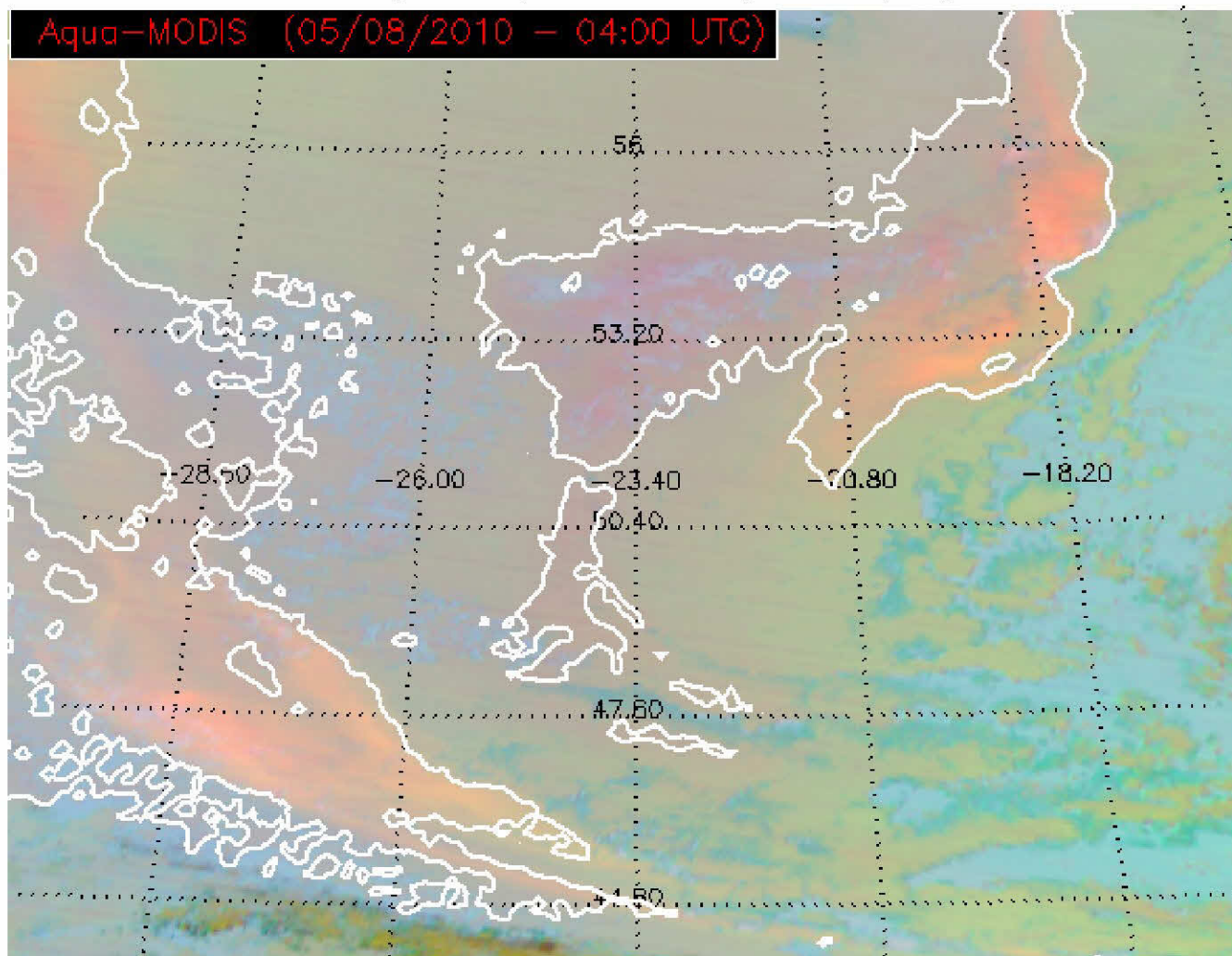
RGB (12-11 μm , 11-8.5 μm , 11 μm)

Aqua-MODIS (05/08/2010 - 04:00 UTC)



MODIS, $\theta_{\text{sat}} < 30.0^\circ$

RGB (12–11 μm , 11–8.5 μm , 11 μm)



- With an additional processing step, the ABI (and SEVIRI and MODIS) products can be used to issue automated ash cloud alerts to VAAC's.
- In addition, the ABI volcanic ash output can be combined with output from the SO₂ detection algorithm and lightning mapper data to build a state-of-the-art volcanic cloud alert and monitoring system.
- If such a decision support system is not built, the ABI's temporal resolution will not be fully utilized, as forecasters cannot possibly manually analyze every image (and the 5-minute warning criteria will not be realized).

Text Warning

Product Quick-look

Date Received
Today
Today
Today
Today
Today

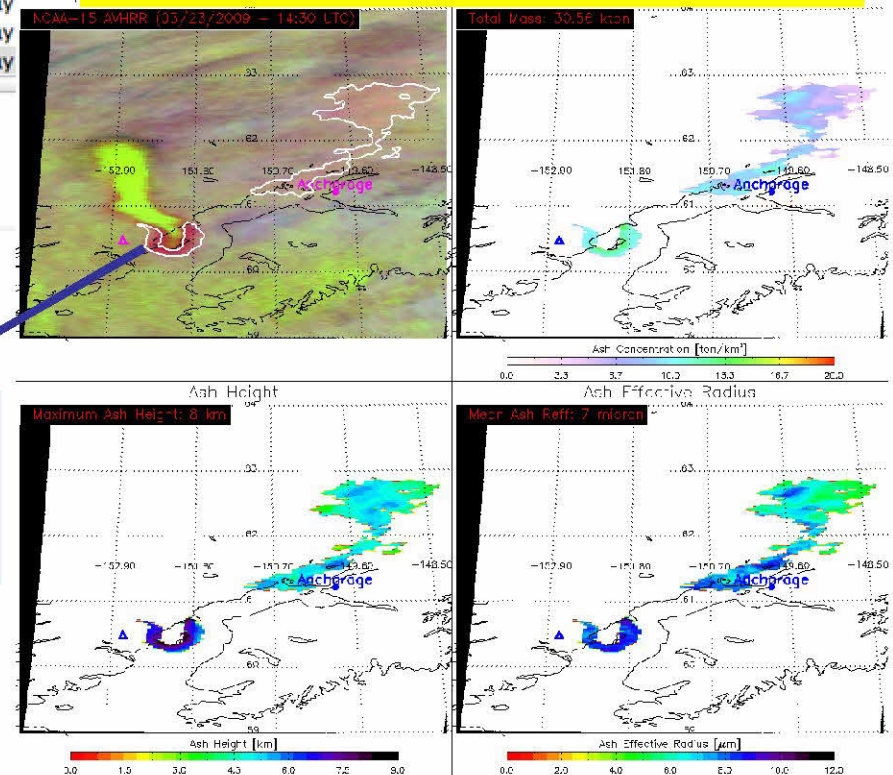
Zhaohui Cheng wrap up for Cloud and volcanic Ash m...
Mike Pavolonis VOLCANIC CLOUD(S) FOUND

From: Mike Pavolonis
Subject: **VOLCANIC CLOUD(S) FOUND**
Date: November 2, 2009 10:20:22 AM CST
To: Mike Pavolonis

DATE: 3/23/2009
TIME: 13:27 UTC
SATELLITE: NOAA-18 AVHRR
L1B FILENAME: NSS.HRPT.NN.D09082.S1327.E1341.B1978787.GC

VOLCANIC ASH CLOUD FOUND
Radiative Center (Lat, Lon): 60.347, -152.057
Nearby Volcanoes:
Redoubt(40.73 km)
Iliamna(67.09 km)
Spurr(106.55 km)
Augustine(133.72 km)
Hayes(145.26 km)
False Alarm Potential: 8 out of 10073
Maximum Height: 8.6 km
Median Effective Radius: 9.58 micron
Total Mass: 2.12 ktons
Total Mass of Fine Ash: 0.00 ktons
Total AREA: 140.00 km²

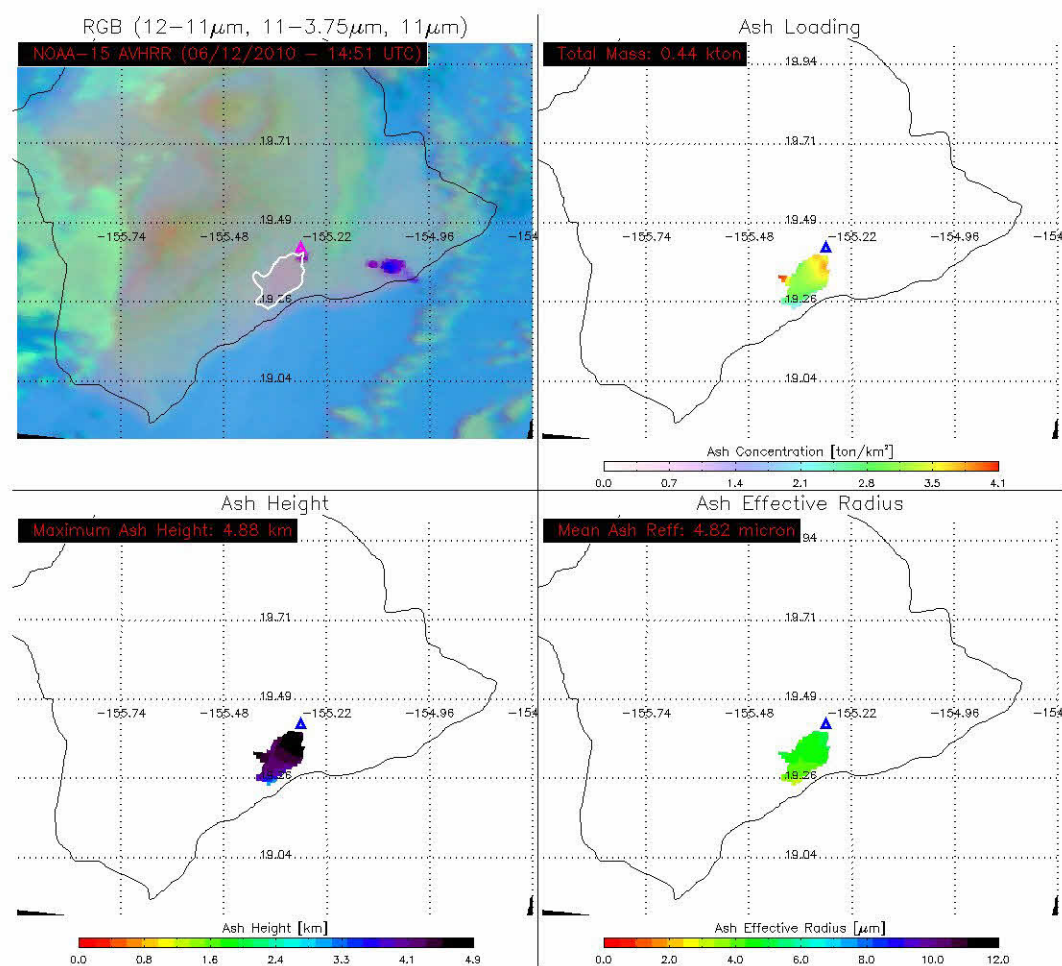
Quantitative description of ash cloud



From HVO:

“The summit gas plume is moving to the ***southwest*** this morning. The most recent (preliminary) sulfur dioxide emission rate measurement was 1,000 tonnes/day on June 8, 2010, still well above the 2003-2007 (pre-summit eruption) average of 140 tonnes/day.

Small amounts of ash-sized tephra, fresh spatter bits and rock dust, continued to be wafted within the gas plume and deposited on nearby surfaces.”



From: Mike Pavolonis
Subject: **VOLCANIC CLOUD ALERT**
Date: June 12, 2010 10:53:08 AM CDT
To: Mike Pavolonis

@*****GENERATING VOLCANIC CLOUD WARNINGS*****
DATE: 06/12/2010
TIME: 14:51 UTC
SATELLITE: NOAA-15 AVHRR
L1B FILENAME: NSS.HRPT.NK.D10163.S1451.E1459.B6281010.EB
ORBIT NUMBER: 6281010
NUMBER OF ASH CLOUD WARNINGS: 1
NUMBER OF VOLCANIC Cb WARNINGS: 0
NUMBER OF VOLCANIC HOT SPOT WARNINGS: 0

VOLCANIC ASH CLOUD FOUND
Radiative Center (Lat, Lon): 19.353, -155.408
Mean Viewing Angle (degrees): 34.87
Mean Solar Zenith Angle (degrees): 101.01
Nearby Volcanoes:
Kilauea(14.77 km)
Mauna Loa(25.11 km)
Loihi(50.27 km)
Mauna Kea(52.39 km)
Hualalai(61.46 km)
False Alarm Potential: 2 out of 276994
Maximum Height: 4.9 km (16011.47 ft)
Mean Tropopause Height: 16.6 km (54403.70 ft)
Median Effective Radius: 4.24 micron
Total Mass: 0.44 ktons
Total Mass of Fine Ash: 0.00 ktons
Total Area: 146.00 km^2

Many of the automated alerts precede the VAA over the Kamchatka Peninsula

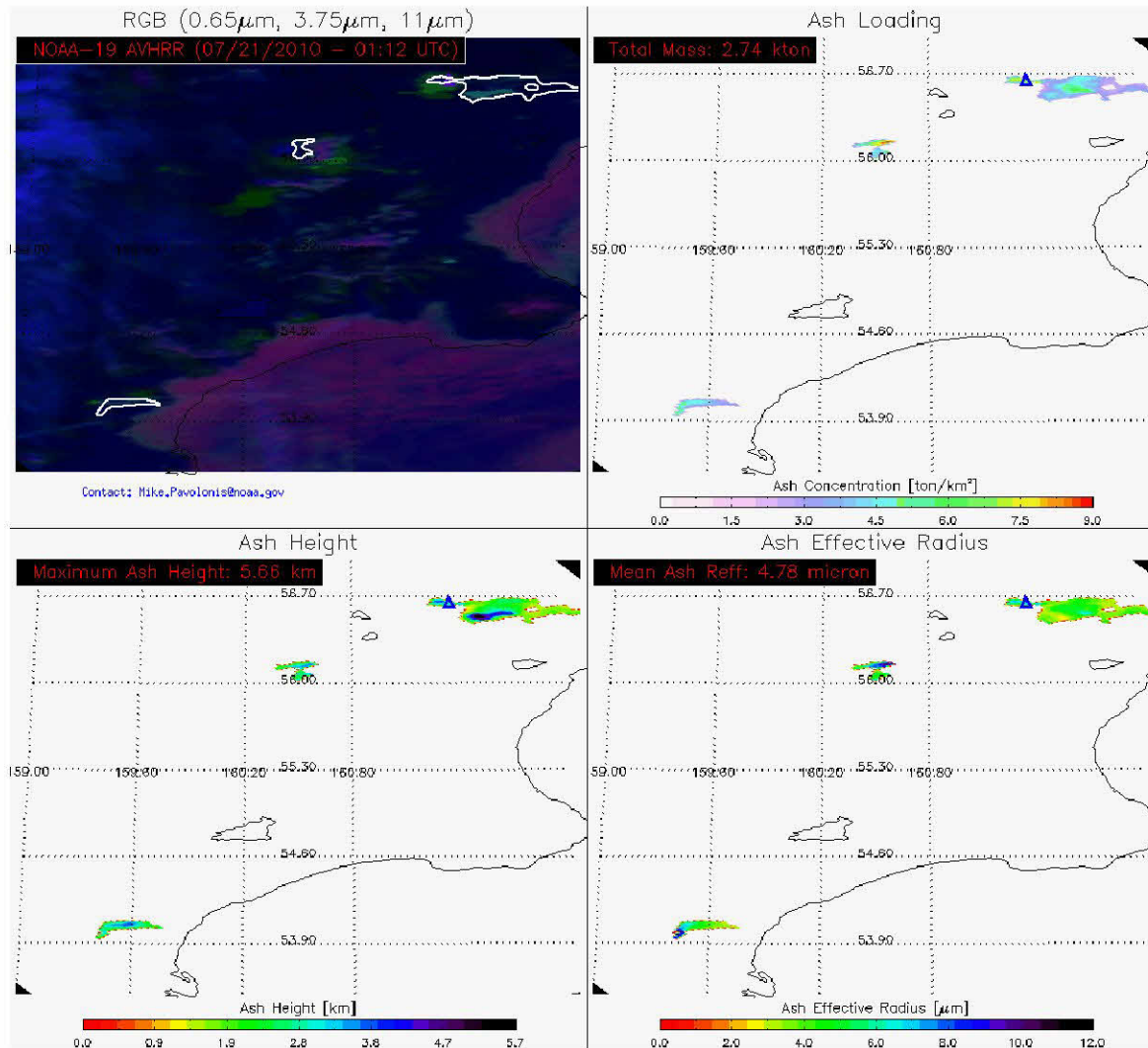
From: Mike Pavolonis
Subject: VOLCANIC CLOUD ALERT
Date: July 20, 2010 8:45:01 PM CDT
To: Mike Pavolonis

@*****GENERATING VOLCANIC CLOUD WARNINGS*****
DATE: 07/21/2010
TIME: 01:12 UTC
SATELLITE: NOAA-19 AVHRR
L1B FILENAME: NSS.HRPT.NP.D10202.S0112.E0122.B0746868.GC
ORBIT NUMBER: 748868
NUMBER OF ASH CLOUD WARNINGS: 3
NUMBER OF VOLCANIC Cb WARNINGS: 0
NUMBER OF VOLCANIC HOT SPOT WARNINGS: 0

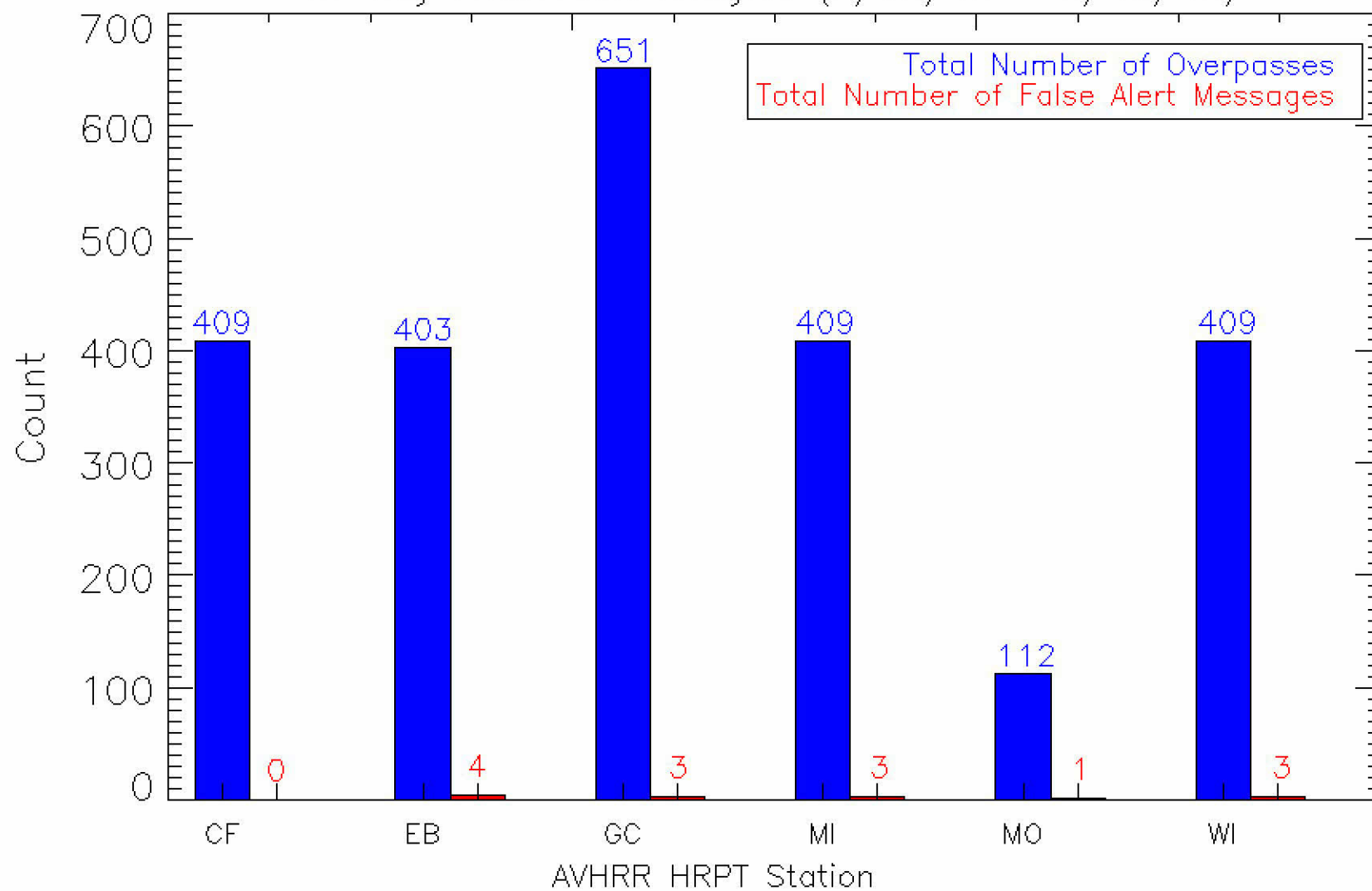
VOLCANIC ASH CLOUD FOUND
Radiative Center (Lat, Lon): 54.064, 159.608
Mean Viewing Angle (degrees): 50.92
Mean Solar Zenith Angle (degrees): 33.31
Nearby Volcanoes:
Maly Semichik(8.53 km)
Karymsky(10.56 km)
Akademia Nauk(13.93 km)
Bolshoi Semichik(39.15 km)
Taunshits(53.40 km)
False Alarm Potential: 0 out of 35515
Maximum Height: 4.0 km (13125.87 ft)
Mean Tropopause Height: 13.9 km (45768.82 ft)
Median Effective Radius: 4.37 micron
Total Mass: 0.35 ktons
Total Mass of Fine Ash: 0.00 ktons
Total Area: 97.00 km^2

VOLCANIC ASH CLOUD FOUND
Radiative Center (Lat, Lon): 56.018, 160.527
Mean Viewing Angle (degrees): 44.22
Mean Solar Zenith Angle (degrees): 35.33
Nearby Volcanoes:
Kamen(4.40 km)
Bezmianny(6.23 km)
Ushkovsky(6.96 km)
Kluchevskoi(7.94 km)
Ziminai(18.03 km)
False Alarm Potential: 0 out of 35515
Maximum Height: 3.9 km (12746.93 ft)
Mean Tropopause Height: 13.9 km (45736.68 ft)
Median Effective Radius: 5.00 micron
Total Mass: 0.41 ktons
Total Mass of Fine Ash: 0.00 ktons
Total Area: 86.00 km^2

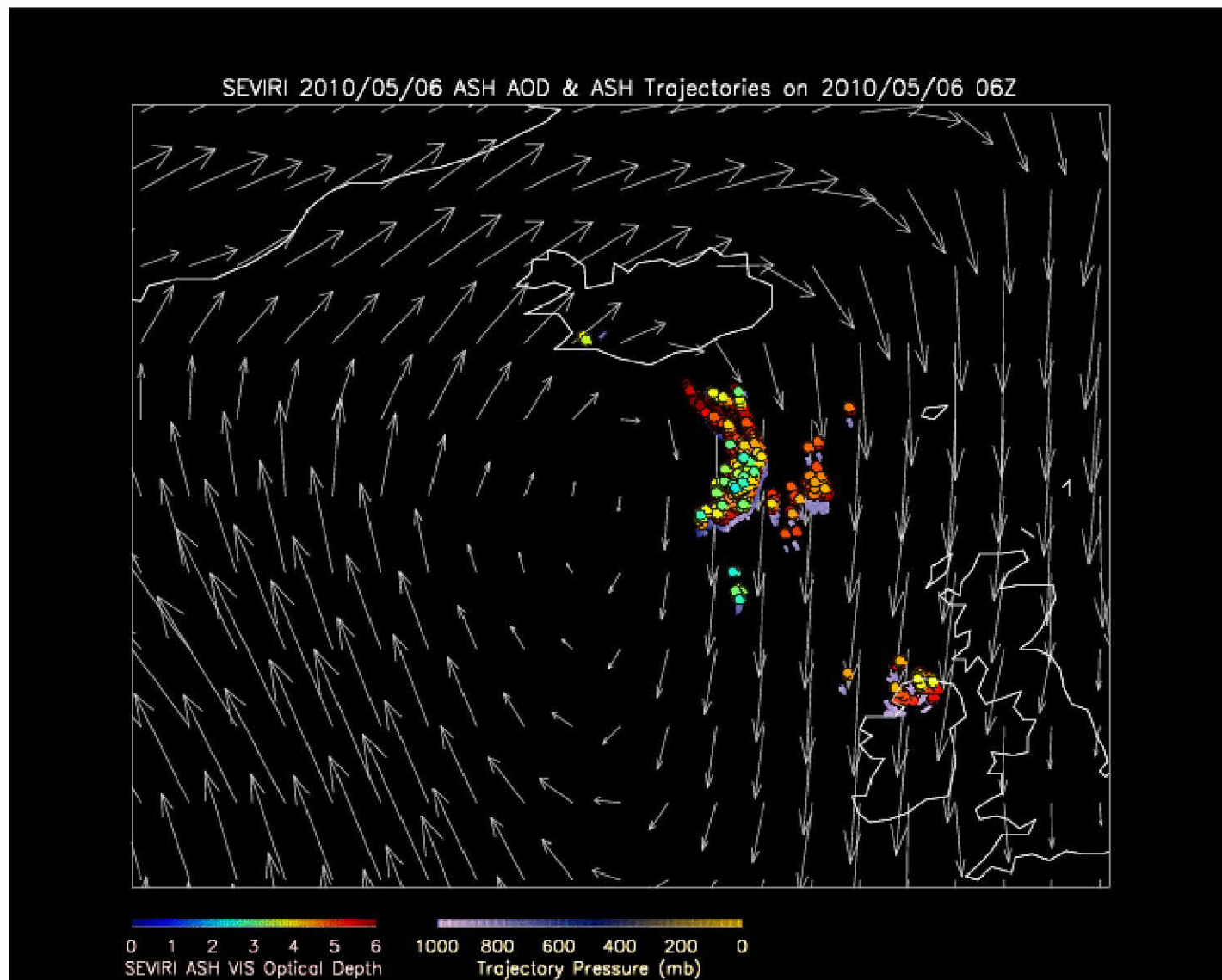
VOLCANIC ASH CLOUD FOUND
Radiative Center (Lat, Lon): 56.546, 161.525
Mean Viewing Angle (degrees): 40.02
Mean Solar Zenith Angle (degrees): 35.79
Nearby Volcanoes:
Shiveluch(15.57 km)
Unnamed(71.02 km)
Shishelka(72.57 km)
Kluchevskoi(77.20 km)
Kamen(82.10 km)
False Alarm Potential: 0 out of 35515
Maximum Height: 5.7 km (18584.71 ft)
Mean Tropopause Height: 12.1 km (39807.43 ft)
Median Effective Radius: 3.82 micron
Total Mass: 1.94 ktons
Total Mass of Fine Ash: 0.01 ktons
Total Area: 515.00 km^2



37 Day False Alert Analysis (2/08/10 – 3/16/10)

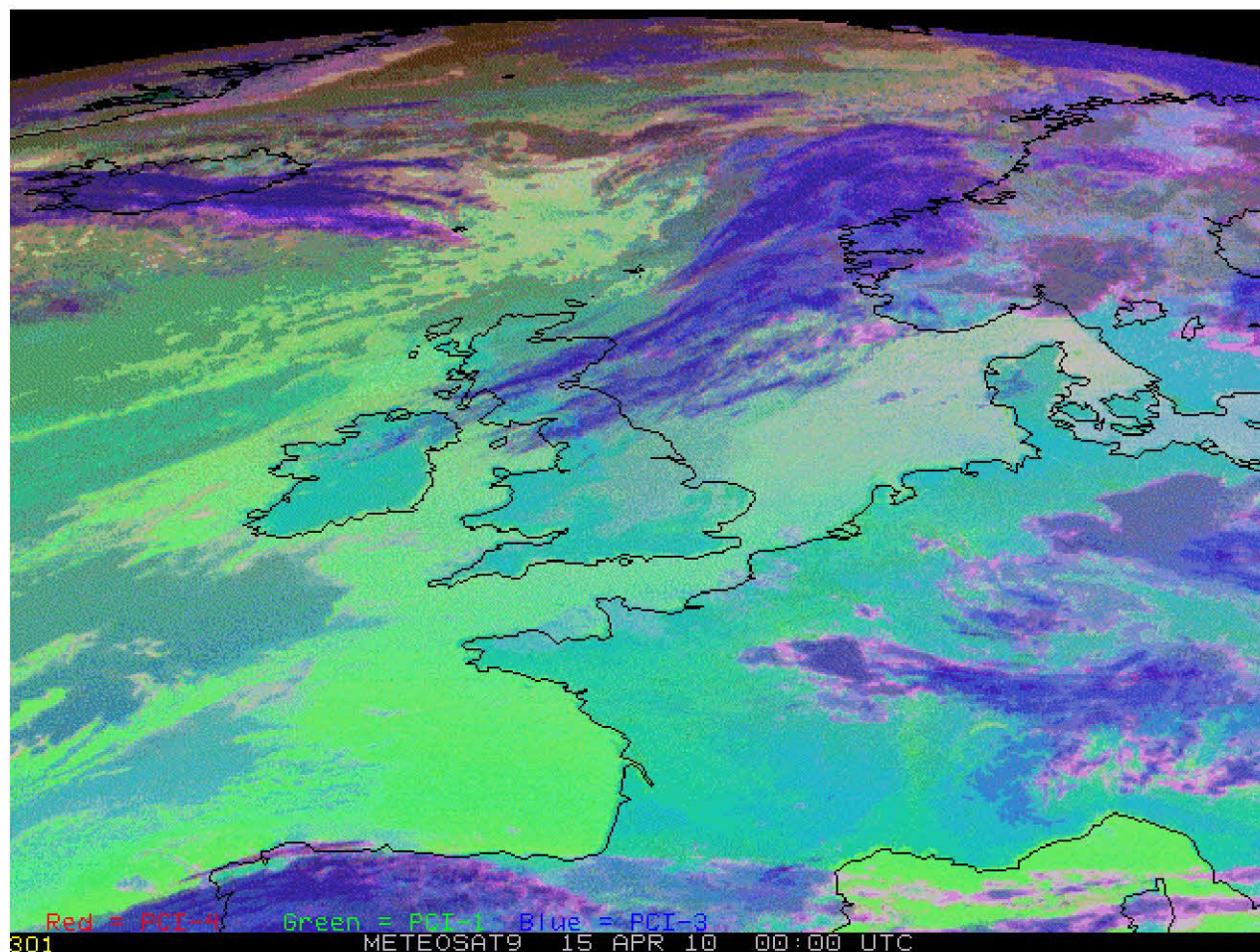


Ash trajectories initialized using GOES-R retrievals



Model trajectories courtesy of Brad Pierce (NOAA/NESDIS)

Decision Aid: Tracking ash from Iceland volcano, 15 April 2010 for 24 h: Using 3-color combinations of Principal Component Imagery (PCI) of selected MSG spectral bands



Selected MSG spectral bands (3.9, 8.7, 10.8, and 12 μm) were first combined using Principal Component analysis into Images (PCIs), and then further combined using 3-color (RGB) techniques. Ash generally appears pink or orange. However, due to the use of the 3.9 μm band, the resulting colors change at day-night transitions.

Don Hillger, RAMMB/STAR, CIRA Proving Group

Current PG Plans

- The automated AVHRR volcanic cloud alert system is being transitioned to the University of Alaska - Fairbanks (UAF), UAF will distribute the alerts and products to the Anchorage VAAC.
- The GOES-R volcanic ash retrievals (from MODIS), without the automated alert capability, will be tested at the Anchorage VAAC and the Aviation Weather Center this fall.
- All products will be viewable in AWIPS, NAWIPS, IC4D, and McIDAS.